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ABSTRACT

Two booklets were developed by the Learning in Science Project (primary)--LISP(P)--to help teachers adopt an approach to science teaching which would enhance children's understanding of floating and sinking; the strategy enables teachers to reconceptualize their teaching task from activity-driven, didactic teaching to conceptual-change teaching. The first booklet was written for more confident teachers, using a less-structured approach, and the second for teachers who might prefer detailed guidance. The booklets were initially tested to determine problems in their use. A second set of trials was conducted to examine: if actual classroom practices matched intentions of the authors in the booklets; ways in which teachers modified and amplified materials in the booklets during their implementation of suggested strategies; and features of the approach which presented difficulties for teachers or students and which could be clarified or revised. This paper includes: case studies focusing on teachers' preparation and planning, teacher/student classroom experiences, and evaluation of the teaching/learning experiences; comments about the trials related to the three evaluation objectives; and a discussion of two major issues which arose during the trials. Results indicate that the booklets can be re-written to convey a teaching sequence and strategies within the capabilities of teachers, provided they are not intended to stand alone. (JN)

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LEARNING IN SCIENCE PROJECT (PRIMARY)

FLOATING AND SINKING:

Second teacher trials

Science Education Research Unit
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FLOATING AND SINKING: Second teacher trials

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INTRODUCTION

Following an investigation into the teaching of primary science (Biddulph, 1982 a; 1982 b) an alternative approach using children's questions and challenging their ideas was proposed (Biddulph, Osborne and Freyberg, 1982). This approach was further refined (Harlen and Osborne, 1983) and trialled in several classes (Biddulph and Roger, 1983; Biddulph and McMinn, 1983). In order to help other teachers use the approach, two teachers' guide booklets were written based on students' ideas about floating and sinking (Biddulph, 1983). One booklet (Biddulph and Osborne, 1984) followed the alternative teaching approach closely and was designed for more confident teachers. The second booklet (Biddulph, Freyberg and Osborne, 1983), for less confident teachers, incorporated more specific suggestions for teaching strategies.

Both booklets were then trialled, the first by a teacher with considerable teaching experience, and the second by one of her colleagues who had very limited teaching experience. Both teachers interpreted the booklets according to their own frameworks of beliefs about science, learning and teaching and, in so doing, did not really challenge the children's ideas about the topic (Appleton, Hawe and Biddulph, 1984). These trials also raised doubts about the wisdom of having two different booklets on the same topic.

Before a further revision of the guide booklets was attempted, it was considered desirable to have them trialled by teachers who were more familiar with the LISP(P) philosophy. This paper reports on the second set of trials of the booklets. Important aspects that were the focus of observation and consideration during the trials were:

- (i) the degree to which what actually happened in the classroom matched the intentions of the authors of the booklets;
- (ii) the way in which the teachers modified and amplified the materials of the booklets during their implementation of the suggested approach;

- (iii) features of the approach which presented difficulties for teachers or children and which could well be clarified or revised.

It was expected that the information obtained would be of use in considering whether a further revision of the teacher guide booklets was appropriate and if so what refinements to the teaching approach and content might be needed.

This paper therefore contains:

- (i) case studies of the trials which illuminate the teachers' preparation and planning, their experiences and those of their pupils during the trials, and evaluations of the teaching/learning;
- (ii) comments about the trials arising from a consideration of the three main aspects mentioned above;
- (iii) issues which arose from the trials.

THE SETTING AND DATA COLLECTION

The authors of the paper were involved in either teaching their own class or observing. Two (J.F. and J.D.) worked as a team to teach a series of four lessons with 40 eight-ten year old children in a rural school. These lessons were observed by the first author (F.B.). Another of us (J.R.) took a series of seven lessons with a class of 30 ten-year- old children in an urban school. These lessons were observed by the second author (K.A.). During the trials there was no communication between the teachers in the rural school and the teacher in the urban school. Each group developed an approach independently of the other.

In the rural school, one teacher (J.D.) was less familiar with the LISP(P) approach, so the other (J.F.) prepared an in-service programme to explore the approach with him (and other staff members). These teachers had both teacher guide booklets so they could take from each that which they needed to develop their own version of the teaching sequence.

The data collected at the rural school trial consisted of:

- (i) planning and evaluation notes, and children's activity guides, written by the teachers,
- (ii) field notes made by the observer following classroom observations and discussions with the teachers, and
- (iii) copies of children's questions and written responses.

The teacher in the urban school trialled the first (unstructured) booklet only. The data collected in this setting consisted of:

- (i) children's work sheets and other material prepared for the children,
- (ii) field notes, and tape recordings of pre-trial and post-trial interviews with the teacher, interviews with the teacher about each lesson, and the proceedings of each lesson. The tape recordings were later transcribed,
- (iii) a pre-trial survey of all children, and interviews with four children, and
- (iv) post-trial survey and interviews conducted two weeks after the last lesson.

CASE STUDIES OF THE TRIALS

In what follows we outline what was planned by the trial teachers in each of the two schools and how practice was modified in the light of on-going experience.

THE RURAL SCHOOL

1. The teachers' preparation and planning

On the basis of prior experience with this topic, one teacher (J.F.) considered that the teacher-planning phase was crucial to the successful implementation of the proposed teaching approach. A set of discussion notes, which included sections from both the teacher guide booklets, was therefore prepared by this teacher:

- (i) to contrast the traditional approach with the proposed alternative, and,
- (ii) to spell out possible implications of the alternative for teaching.

For example, the notes indicated that early in the study the children's existing ideas were to be identified:

"Identify children's present ideas and interests so that they can be used as a starting point for the development of the topic."

and

"At this point we are interested in the children's responses [to OHP transparencies depicting instances and non-instances of floating] whatever they are, not in changing them."

A further example is the final statement in the notes about evaluation:

"This unit will have been successful if:

- (i) you have identified children's views and questions,
- (ii) you have challenged those views,
- (iii) you have resolved some of the questions they have asked,
- (iv) you have allowed the children to develop ideas which will help them make better sense of their world - which will help rather than hinder learning,
- (v) you arouse pupil interest."

These discussion notes were then examined in detail by the teachers and provided the foundation for a planned sequence of experiences for the children. The plan, in outline, was:

Step 1: Show the children a series of OHP transparencies depicting instances and non-instances of floating. Have the children record their responses on a form as follows:

CARD	IS IT FLOATING	REASON
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Step 2: Administer a survey (see Appendix 1) to the children to further identify their ideas about floating and sinking.

Step 3: Obtain the children's questions on the topic.

Step 4: Provide a range of investigations that will enable the children to answer their questions. Challenge the children's ideas as they work.

Step 5: Help the children draw some sensible conclusions from their investigations.

2. The teaching sequence as it evolved

The purposes of the first lesson, which comprised Steps 1, 2 and 3 of the plan, were to enable the teachers to gain some knowledge of the children's questions. Both teachers felt at the end of the lesson that:

- (i) they had obtained some useful insights into the children's meanings for 'floating' and their ideas about the topic. For example, they were a little surprised when, with reference to one OHP transparency a child asked,
"Do you have to say 'yes' or 'no'?"

They found that she considered the spider to be neither floating nor not-floating.

"It's not sinking but you can't say it's floating either.
[How do you mean?] Well it's standing on the water, not lying on it."

(See also Table 1 on page 9),

- (ii) the session, which lasted about one hour, had been too long for the children, and
- (iii) the children's consequent tiredness was reflected in their generally low-quality questions.

The next morning one of the teachers (J.D.) invited the children to ask any further questions they might have. The children did have further questions and these were recorded by the teacher. It seemed to him that on this occasion the children had more questions of better quality than they had the previous day.

For the second lesson, taken in the afternoon of the second day, the teachers had written out overnight a series of cards to guide the children in a range of investigations that might help them answer some of their earlier questions. For example, one of the children's questions had been: "Can liquids float on or in other liquids?" and the card written to assist an investigation of this was:

CAN LIQUIDS FLOAT ON OR IN OTHER LIQUIDS?

To find out:

- (a) Get some water in a clear glass test tube, beaker, bottle or jar.
- (b) Add some cooking oil.
- (c) See what happens.
- (d) Add some other liquids to water e.g. dyes, milk, vinegar, cooking oil.
- (e) Try vinegar and cooking oil.
- (f) Try shaking these mixtures for one minute, and then look at them again.
- (g) Record what happens. Write 2 or 3 sentences, or draw diagrams to explain your ideas.

One of the teachers (J.D.) found the task of devising the cards a very useful exercise as it helped him clarify in his own mind what is involved in an understanding of floating.

To accompany the cards were appropriate equipment and materials which the teachers had collected and set out at several 'stations'. The children decided which investigation they would like to undertake and did so in groups of no more than four. What generally happened when the children began their investigations, however, was that they initially followed the guide cards but then began freely exploring the floating properties of various objects and materials to which they had access. For example, two children were observed testing various objects to see if they floated. One object they tested was a metal dish. The first child placed it in the water and it floated but when the second child had a turn he inadvertently dropped it in sideways and it sank. When asked by the observer whether it was a floater or sinker, one child said it was a floater and the other said a sinker. Without any inclination to consider the matter further, they immediately sought other objects to drop into the container of water.

No attempt was made to redirect the children's attention to the later steps of the guide cards. Instead the opportunity was taken to further explore their thinking and in some cases to begin challenging it as they engaged in their explorations. For example, when a group of children found that the length of a floating material (candle) made no difference to its level of flotation, one teacher suggested that if it had a hole through it, then it might make a difference. The children accepted this as a real challenge; some thought it would make a difference and some thought it would not. They immediately wanted a hole put through the candle so they could find out. When they had difficulty themselves trying to make a hole with a nail the teacher helped out. As the hole was finally pierced the children's comments suggested that they knew the moment of truth had arrived,

Pupil 1: It's going to sink.

Pupil 2: Float.

Pupil 3: [As the teacher lowered the pierced candle towards the water] This is it!

On reflection, it seemed to the teachers and observer that although Lesson 2 had not continued along the planned lines, it had nevertheless been a valuable session for the children as it allowed them to try out and think about a variety of things to do with floating and sinking. As well as providing further insights into the children's ideas about the topic it also enabled one teacher (J.D.) to see how he could begin challenging some of their ideas. In this respect he found that his card preparation stood him in good stead as the understanding gained in that exercise allowed him to recognise what it was the children were saying and hence how he might challenge their ideas.

The teachers decided that the children's experiences during Lesson 2 may have raised more questions in the children's minds, so Lesson 3 began with the teachers taking half the class each and seeking any further questions the children might have. Both groups of children responded with further questions, most of which obviously arose from their Lesson 2 experiences, for example,

"Play-dough when it's rolled into a ball goes right to the bottom but when it's a boat shape it stays floating. Why is that?"

"Why do light things like wire gauze sink rather than float?"

(See Appendix 2 for a list of questions asked by the children throughout the study.)

The recording of these questions was done by the teachers on notepaper. In a later discussion with the observer, the teachers stated their view that obtaining their children's questions in public provided a stimulus to other children in the class to consider aspects they may not yet have thought of, and having children write their own questions out was not the best way to use the time available.

Quite independently, both teachers went on to

- (i) help various children clarify what it was they were asking, e.g.

Child: Do some shapes help things that wouldn't float to float?

Teacher: Could you explain what you mean by 'shapes'.

Child: Ah ... well, you know, the shape ...

Teacher: Would you like to come out to the blackboard and show us. [Child does so]

- (ii) extend this to help the children formulate publicly investigations they might undertake to seek answers to their questions. Other children were given an opportunity to comment on the proposed investigations.

The result of this teaching approach was that about two-thirds of the children in each group elected to pursue their own investigations during Lesson 3. The remainder opted to investigate previous questions for which the teachers had overnight written guide cards and set out equipment. During the children's investigations both teachers moved among the children listening to them and challenging their ideas and procedures. Lesson 3 concluded with the teachers reviewing orally with the children what the children had found out during their investigations. Again, other children were invited to comment on the brief reports and, in some cases, the teachers further challenged ideas that arose. Lesson 4 followed a similar sequence to Lesson 3.

This really concluded the formal study but in their own time children continued to investigate aspects that puzzled them and to talk about these with the teachers.

3. Evaluation of the study

When they later considered the extent to which the study had been successful the teachers concluded that they had met the criteria they set themselves. With the assistance of the suggestions and information from the teacher guide booklets they felt that they had

- (i) successfully identified the children's ideas and questions,
- (ii) helped the children resolve some of their questions, and
- (iii) challenged some of the children's ideas.

For example, they managed to off-set children's prior understanding that things float because they are 'light' or 'small'. They had also managed to influence a number of the children with respect to the meaning of 'floating', as revealed by an end-of-study check using the OHP transparencies of instances and non-instances (see Table 1).

TABLE 1: Comparison of percentage of children who, before and after the study, considered various items to be floating

CONDITION	OHP TRANSPARENCY ITEM	% OF CHILDREN WHO CONSIDERED IT TO BE FLOATING	
		Prior to study	At end of study
Partly immersed	Apple	92%	93%
On top of surface	Spider	69%	90%
Fully immersed, freely suspended	Submarine	56%	68%

The children's responses indicated that at the end of the study a greater percentage of children considered objects both on top of the surface and freely suspended within water to be floating.

As for arousing interest in the topic, the teachers conducted a small survey among the children to check their own impressions. The survey results are summarised in Table 2. This indicated that the majority of children had developed varying degrees of interest, a result which was consistent with the teachers' and observer's own observations.

TABLE 2: Children's expressions of interest in the topic 'Floating and Sinking'

BEFORE THE STUDY	WHEN THE STUDY ENDED	NO. OF CHILDREN
Not interested	Now interested	16
Interested	Now very interested	12
Little bit interested	Now very interested	4
Not interested	Little bit interested	3
Little bit interested	Little bit interested	1
Little bit interested	Not interested	1
Not interested	Not interested	<u>1</u>
		38

At the end of the study the two teachers told the observer that the discussion notes prepared by one of them had been very helpful in two important respects: they had enabled the teachers

- (i) to gain considerable appreciation of the topic and children's views on it, and
- (ii) to clarify their teaching roles.

For example, the discussion notes included the following:

"Perhaps more important than the activities themselves is the role the teacher adopts as challenger of pupils' present ideas. ... Some teachers find it useful to think of their role primarily as one of being Devil's advocate."

The teachers found the 'Devil's advocate' analogy a useful one. The form of teacher questioning that this suggested was illustrated in the notes by the following:

"For example, some questions you might ask as Devil's advocate include:

Why do you think that?

How will doing that help you?

Have you heard of this idea ... what do you think about it?

How could you check on that suggestion?

Is that a sensible conclusion?

THE URBAN SCHOOL

1. Teacher preparation

The teacher (J.R.) was already familiar with the LISP(P) approach as outlined in guide booklet 1, and had used the approach with another class and topic the previous year. Nevertheless, to check that her idea of what was likely to be involved matched that being proposed in the booklet, she

(i) read the booklet through and noted any apparent aspects that differed from what she expected;

(ii) used a pre-trial interview with the observer (K.A.) as an opportunity to clarify details of the approach and its implementation. For example,

Juliet: ... I know that obviously there's going to be questions which probably don't relate to floating and sinking. What do you do there? Do you put up those questions or do you say "We're not looking at that."?

Ken: ... Well again as far as I can gauge from this (booklet) you can go whichever way you want to ...;

(iii) discussed the booklet with the teacher who had conducted the first trial of it. (See Appleton, Hawe and Biddulph, 1984.)

Following this, the teacher planned Steps 1, 2 and 3 of the approach. She did not prepare details of Steps 4 and 5 at this stage. However, she was already generally aware of the types of activities the children might be involved in. She commented to the observer,

"I'm pretty much aware of the kinds of things they might be doing and the kinds of things I'm going to have to provide."

She also had some idea of how she would go about helping them.

"When they (the children) come back and say 'Well we're going to investigate it this way, we're going to investigate that way' I'm going to say to them 'Well, let's think about that. Is that going to be what you do? Is it possible?'"

In terms of preparation, the teacher did not consider that using this approach involved more work than a more conventional approach.

2. The teaching sequence as it evolved

The first three lessons followed each of Steps 1, 2 and 3 of the suggested approach. In the first lesson, the children worked informally on a stimulus activity in which they tried a range of objects to test their floating properties in water. In doing so they worked rapidly and excitedly; they tried any object they could get their hands on, discarded it and immediately tried something else. Only when some unusual event occurred did they repeat the activity.

Although the children were formed in groups of about five around the water containers, in practice they worked as individuals. For instance, a child would test an object that had just been tested by another member of the group. Only where equipment was very limited did they share findings. However, when something exciting happened a child would tell the whole group and even other groups.

At the end of the activity, the teacher recorded on the blackboard questions about floating and sinking which the children raised (see Appendix 3).

Prior to the second lesson the teacher selected from these questions eight which she considered were investigable by the children and which would give them some worthwhile knowledge about the topic. She listed

these on the blackboard. During lesson 2 the children individually chose a question from this list to work on, were able to form groups if they wanted to and with the aid of a teacher-prepared worksheet (see Appendix 4) prepared a general plan for finding answers to their questions. The questions as listed, and those chosen by the children, were:

- (1) Why do things float and sink?
- (2) Why do some large heavy things float? (3 children)
- (3) Does the shape of an object make a difference to whether it floats or sinks? (6 children)
- (4) Can things float in other liquids? (15 children)
- (5) Why do some hollowed-out things float?
- (6) Why do fat people float better than thin people? (2 children)
- (7) Why does a potato sink and an apple float? (2 children)
- (8) Why does a heavy thing become light in water?

Some ideas about how answers might be found were shared at the conclusion of the lesson, but at this stage the children were not asked to plan investigations in detail. In their general plans twenty-one of the twenty-eight children specifically referred to experimenting but only ten had fairly definite ideas about the kind of experiment they might do.

At the conclusion of lesson 2, the teacher was satisfied that the children had chosen their questions and had mapped out some plan of attack. She was particularly pleased with the concluding discussion, in which children had offered suggestions for investigating some questions, proposed answers to others and suggested how some of the answers might be tested. Part of that discussion follows:

Matthew: I think that an apple has air cells (which make it float).

Teacher: How are you going to do that (check out your answer)?

Matthew: Oh. I'm going to cut it in half and find out if it still floats.

Teacher: Yes. Now, will that show whether that's the case or not?

Matthew: No.

Teacher: Matthew thinks that an apple's got air cells. How could you find out whether an apple's got air cells?

Janine: Cut it open.

Andrew: Use a microscope.

Scott: Matthew, he could try cutting up little holes in the apple to where the seeds are and see if it sinks or floats.

After the discussion the teacher commented to the observer,

"It's quite amazing how it just sparked off a bit of a discussion, isn't it ... I noticed how they're getting a little bit critical of the other kid's thinking ..."

Lesson three set the pattern for the remaining four lessons, which comprised Steps 3, 4 and 5 of the approach. In lesson three the teacher provided the children with a worksheet (see Appendix 5) to help them plan and record the detail of their investigations. (In subsequent lessons either some variation of the worksheet was used, such as checking progress with children working on the same question, or its use was omitted altogether.) The children then went ahead filling out the worksheet, beginning their investigation, or making a start on their record of the investigation. Each lesson concluded with a class discussion.

The general pattern followed by the children during the investigation phase was:

(i) plan the 'experiment'.

Most children did this in a general kind of way rather than considering details needed to ensure fair tests. One group, for instance, made no plans for checking for flotation level of two objects (and was observed to carry out no check but nevertheless draw conclusions as if they had).

(ii) do the 'experiment'.

This usually followed the rough plan, but was not systematic. If something had not been experienced before, then the initial part of the 'experiment' was simply trial and error play. For example, a group of children who tried to compare objects floating in different liquids first mixed all the liquids together and tested objects in the mixture.

- (iii) record results and, if appropriate, state some conclusion.

The teacher had provided a worksheet (see Appendix 6) which gave guidance in recording. Children varied considerably in their ability to carry out this task.

Several groups tried more than one 'experiment', and one or two children did not try any because they were unable to obtain the materials. Many children reported trying 'experiments' at home as well. By lesson 7 all children were finalising their written records.

During the class discussion at the conclusion of each lesson, children shared findings and conclusions, and their ideas were challenged. The teacher played a key role in this process as the following discussion from lesson 4 about floating in the Dead Sea shows.

Teacher: ... But how, why does the salt hold it up? I mean it's not as though the salt's ... the salt's dissolved I would have thought. Why do you think it holds people up Joseph?

(The teacher called for an explanation from Joseph.)

Joseph: (Inaudible ...) jumped into the top (of the Dead Sea) and he tried to go right under but he couldn't.

(Joseph's reply was a description rather than an explanation.)

Teacher: Right. Why would that be happening though? You can't actually see the salt, can you? Julian?

(The teacher accepted the answer, challenged the children to give it more thought, and redirected the request for an explanation to Julian.)

Julian: Um. The salt may be at the surface. Except if you could push your way under the salt you might sink, still sink.

Teacher: Do you think so. So it might be layers, do you think. What do you think about that Billy?

(The teacher summarised Julian's idea and asked Billy to evaluate it.)

Billy: Um. There's so much salt in it that's still can't, so you can't really go under it.

(Billy's response may be a comment on Julian's idea or could be a teleological explanation of his own.)

P: (Interjecting) Like a cushion.

(Another child has interpreted Billy's response in his own way.)

Teacher: ... Like a cushion?

(The teacher picks up that idea for further consideration.)

As the lessons progressed the teacher varied her overall plan in several ways. These variations included:

- (i) The use of an activity suggested by a parent - a child brought to school an activity which his father had given him, recalled from his own schooldays (making a potato float by adding salt to water) and the teacher encouraged the children to try it. Several did but without success. They had no idea of how much salt to add, and tended to add a pinch at a time. One group appealed to the teacher for help and when it was working successfully, the teacher called together all the children working on the topic and demonstrated the activity. After the demonstration, many children repeated the activity themselves (successfully).
- (ii) The use of a checklist to assist pupils with investigations - at the conclusion of lesson three, the teacher (and observer) were concerned that some children seemed to need more structure to help them plan their experiments. The teacher, for example, commented,
"Kids like Matthew are a bit slow. They just don't have any idea what they should be writing ... In some cases I feel like saying 'Right do this. Do that.' You know, I probably should do a bit more of that with those kids who are struggling."

The observer responded to this particular need by preparing reminder checklists for a few of the popular questions (see Appendix 7 for an example). At the beginning of the next lesson the teacher used these with the children who were investigating those questions. However, the children did not seem to take any heed of them. For example, some children who, if they had used

the checklist would have tested objects in different liquids, immediately mixed all their liquids and put the objects into the mixture.

- (iii) The use of a specially written children's resource booklet - it also became apparent that there was a lack of written resource material which would provide answers to some of the children's questions in language they could understand. Commenting on the non-availability of suitable books at the children's level, the teacher said, "What I've found is you get books that are either far too advanced for them or far too babyish."

The teacher's concern about lack of appropriate written resources became greatest during lesson six when it was obvious that many children were selecting explanations which, in the longer term, would be unlikely to help them make better sense of their world. They had had no exposure to a view that would lead them towards a more useful understanding, and both the teacher and observer felt that a written resource would be a good means of providing that view. The observer consequently modified a children's booklet which one of the teachers' guide booklet authors had attempted to write at the children's level, and the teacher used this in lesson seven as a reader. However, by this time the children had seemingly fixed on an explanation, and most did not seem to accept as sensible alternatives the idea proposed in the reader. In the post-trial survey, for example, only 6 of the 28 children referred to those ideas and even then there was some doubt that they really understood them, as the following interview excerpt with one child illustrates:

I: ... I see you've written here (on the survey sheet) you think some things float because they're light for their size. Can you tell me what you mean?

P: ... An apple is quite light. Cos we get real big apples an' they're quite light an' you get a potato an' they're quite heavy. (pause) um. That's all.

I: ... Mm. Can you tell me how you think something like a boat floats then?

P: ... Cos it's got this red line, an' it's got ah, it got, it carries cargo and it's when it comes down to the water where the red line is, that's how full it's gotta be. That's the right size for it.

- I: ... Can you tell me a bit more about that?
- P: ... Um. I dunno.
- I: ... Well, why doesn't a boat, say a metal boat, sink, but a piece of metal does?
- P: ... Cos it's made to float. It's got, it's floatable metal, prob'ly.
- I: ... What do you mean by 'floatable metal'?
- P: ... Well it's metal that can float.

(Post-trial interview)

3. Evaluation of the study

Evaluation was conducted at two levels, namely an informal assessment by the teacher of the merits and problems of both guide booklet 1 and the teaching approach advocated in it, based on her use of them, and a more formal check, of the children's learning, by means of a pre and delayed (2 weeks) post-trial survey (see Appendix 1) administered by a member of the LISP(P) team. Four children were also interviewed about their pre and post-trial survey responses.

(a) Merits of the booklet and proposed approach

During the post-trial interview, the teacher mentioned the following points:

- (i) the booklet provided is a good summary of the approach;
- (ii) the view of scientists included in the booklet was desirable and necessary,
- (iii) the booklet gave practical suggestions where possible, such as in providing motivating stimuli,
- (iv) the approach revealed those children who are thinkers.

(b) Problems encountered in using the topic booklet and proposed approach

The following problems were identified by the teacher:

- (i) The topic (Floating and Sinking) posed difficulties because its relevance as a topic worthy of study was not obvious. The teacher felt other topics should have greater priority. Further, she experienced difficulties herself, as her own understanding of the topic was extended to uncomfortable limits. Consequently she believed many teachers would not have an adequate understanding of the topic to be able to cope with it.
- (ii) The children were not interested in the topic initially. However, the interest of some children increased as the study progressed. Table 3 summarizes the children's reported expressions of interest.

TABLE 3: Children's expressions of interest in the topic

BEFORE THE STUDY BEGAN	WHEN THE STUDY ENDED	NUMBER
Not interested	Now interested	7
Interested	Now very interested	2
Not interested	Little bit interested	4
Little bit interested	Little bit interested	2
Little bit interested	Not interested	1
Not interested	Not interested	6
Very interested	Not interested	3
No clear expression of interest, or interest change		<u>5</u>
		<u>30</u>

Overall interest was retained or increased by 15 children during the topic, and 10 children lost interest, or remained uninterested. However, a few children commented that they were no longer interested because they had answered all their problems.

- (iii) Resources for the children to use to investigate aspects of the topic were not readily available.
- (iv) Many children did not reach the conclusions which the teacher expected they might, such as realising that things float because they are light for their size (see comments later).
- (v) The booklet did not suggest how much guidance to give children. For example, it did not advise whether to provide activities for children who were floundering.
- (vi) Some children seemed to lack the intellectual skills to cope with the approach.
- (vii) The approach did not seem to work well with impulsive children who usually did not want to think and reflect on what they were doing or had done.
- (viii) Despite having good management skills, some management problems were experienced in trying to implement the proposed approach. Contributing factors included:
 - a feeling by the teacher that she was losing touch with the classroom situation with so many things going on at once,
 - children finishing at different times,
 - behaviour-problem-children choosing to work together on the same questions.

(c) The learning which occurred

As noted earlier, six children in the post-trial survey related weight to size to explain why things floated or sank, whereas none had given this explanation in the pre-trial survey. However, the possibility existed that the children were merely using words rather than understanding the relationship. As it happened three of those children were also interviewed following the post-trial survey and careful probing on the point revealed that they had no understanding of that relationship. Children who are struggling to make sense of an abstract idea may not be able to express it very well but all the same we cannot be confident that the six children understood the idea.

Evidence of specific changes in the children's ideas from pre to post-trial can be found in questions 3 and 4, dealing with floating materials (see Table 4). The interesting thing about these changes with respect to question 3 was that not all children changed to the expected response (float lower) despite the fact that many had tested the materials themselves. It seems that a large group either did not observe the floating level carefully, or relied on hearsay conclusions from other children whose observations were no better.

TABLE 4: Comparison of pre and post-trial children's responses on two items with which they had had some experiences during the study.

	No of responses	
	Pre-trial	Post-trial
When you fill a floating material with water it will:		
Sink	20	1
Float lower	6	12
Float same	-	16
Float higher	1	1
When floating material has a hole in it, it will:		
Sink	19	4
Float lower	1	11
Float same	4	12
Float higher	3	3

COMMENTS ABOUT THE TRIALS

1. There was congruence between authors' intentions and teachers' actions

The classroom implementation by each teacher matched well the suggested approach. If the main points of the approach are taken to be:

- (i) the use of children's questions to raise their interest and focus the learning;
- (ii) the devising and conducting by the children of their own investigations into their chosen questions;
- (iii) the identification and challenging of the children's ideas and explanations.

then the events clearly occurred in each of the trial settings.

2. The teachers modified and extended the guide booklets

The teachers, particularly those in the rural school working with both teacher guide booklets, made several modifications and extensions to the booklet materials. The more important of these were:

- (a) The preparation of an in-service programme to familiarize one of the teacher's with the LISP(P) approach;
- (b) The design and provision by the teachers of aids to help pupils plan and conduct investigations which would be fair tests. In the rural school, these took the form of suggested activity plans, and in the urban school consisted of check lists of things to consider in particular experiments. In the event, neither quite fulfilled the teachers' expectations;
- (c) The provision of activities for pupils who needed specific help, or who were less interested in pursuing their own ideas. This occurred in the rural school only, but was stated by the teacher in the urban school as a need;
- (d) The making available of pupil-reader booklets in the urban school in an attempt to present the scientists' view to the children for consideration. Like the aids, these too had only limited success.
- (e) The articulation by the teachers in the rural school of evaluation criteria which enabled them to judge the success of their trial. These criteria closely resembled those (unarticulated) criteria being used by the other teacher and the observers.

3. The teachers adopted various strategies to deal with special circumstances arising from their use of the approach

Special circumstances that arose, how the teachers dealt with them, and what they indicate in terms of aspects of the approach that need further clarification are outlined below:

(a) Exploration phase.

The importance of allowing children adequate time initially to explore the event or phenomena under study became evident in both trial settings. This exploration would be an important part of, if not the whole, initial stimulus.

(b) Children's questions.

The children's questions tended to be mainly at two levels:

- (i) Those which related to specific events and for which answers could be proposed in terms of predictions about those events. These could be tested by observation relatively easily. E.g. Can things float in other liquids?
- (ii) Those which sought relationships between events or phenomena, particularly casual relationships e.g. Why does an apple float and a potato sink? Explanations to these questions would usually need some logical, perhaps abstract, statement or mental construction such as 'an apple has less density than a potato', in order to satisfy an adult.

The children's explanations, however, tended to refer to events recalled from past experiences, or analogies drawn from other experiences; e.g. 'an apple has air cells and a potato doesn't'. To test such explanations would often require both pre-conceptions not usually available to the children, and carefully conducted and controlled experiments. The children showed little evidence of being able to plan or conduct investigations at the required level of sophistication, though this does not imply that, given practice, they could not do so.

The rural school teachers found that the questions which arose from the exploration phase were more meaningful and productive than those which emerged from the first lesson which was a kind of class interview-about-instances.

When eliciting the children's questions, the teachers - the rural teachers in particular - tended to help the children rephrase their questions so that their meaning was clarified, and they were amenable to investigation by the children. The rural teachers also challenged the children to develop specific plans for their investigations.

(c) Management of the investigations

- (i) - the children. Some children in the urban school experienced difficulty in managing their own learning behaviour. There were one or two seemingly very slow children who didn't really grasp what was going on. Other children were not particularly keen to work in a group with them. Some children did not persist with a task. They were reluctant to do any task other than 'hands-on' work, and did not want to think ideas through.

In the rural school the teachers provided those children who had no investigations of their own with activity cards based on other children's questions or on investigations in the second teacher guide booklet.

- (ii) - the teacher. Management issues for the urban school teacher seemed to depend on how much control she felt she had over classroom events, particularly in respect to ensuring that all children were engaged in meaningful tasks. Similar difficulties were experienced in earlier trials (Biddulph and Roger, 1983; Biddulph and McMinn, 1983). Even though very competent in classroom management, the teacher in the urban school felt that there were times when she did not have sufficient control over classroom events and in those instances she considered management to be a problem. Management was not such a problem in the rural school, perhaps because the class sizes were smaller.

(e) Challenging children's ideas.

There were several identifiable phases to the challenging process. Each phase seemed to require definite action by the teacher.

- (i) The stimulus/exploration step seemed to provide the first challenge to children's ideas, such as when the children in the urban school noticed that an apple, and even parts of an apple, floated, whereas a potato or parts of a potato always sank. The teachers' role in this phase was one of providing a stimulus or exploration opportunities which contained events likely to confront the children's existing ideas.
- (ii) Clarification of the children's questions has already been mentioned, and was also commented on in earlier trials (Biddulph and McMinn, 1983). Question clarification also seemed to serve the purpose of making a child think through more carefully his/her meaning for words, interpretation of observations, or possible explanations related to the question being proposed. Clarification of questions took two main forms, namely clarifying meanings for words and phrases, and clarifying whether certain questions were based on knowledge or assumptions. For instance, when a child asked "Why do logs float?" the following conversation ensued:

Teacher: "Do you know that logs float, that all logs float, or do you just think they do?"

Child: "Well, I think so."

Teacher: "Maybe we should start with, 'Do all logs float?' Would you be happy with that question?"

Child: "Ohh yes."

The effect of this clarification procedure was to help children address specific questions rather than the more general 'why' questions they asked initially. It was also noticeable that the children in the urban school, when given the opportunity to choose questions to investigate, tended to select the more specific type. These of course are far more amenable to investigation by the children than the more general type questions.

- (iii) Critically examining the children's ideas. This occurred in both small group and whole class discussions. The central role of the teacher in asking probing questions and providing a trusting climate for discussion has already been noted.
- (iv) Provision for resources. Ideas for investigations came from several sources, namely, the children themselves, the teachers, the guide booklets and the children's parents. Book material and audio-visual aids at a level suitable for the children were virtually non-existent. This was also the case with earlier trials of 'Floating and Sinking' (Appleton, Hare and Biddulph, 1984), of 'Seeds' (Biddulph and Roger, 1983), and of 'Metals' (Biddulph and McMin, 1983). It seems likely that this would be a general problem for many topics. With this particular topic the teacher in the urban school certainly experienced it as a problem, but the teachers in the rural school found that they did not really require these types of resources for the investigations that their children undertook. However they did provide a considerable amount of equipment.
- (v) Recording of data and conclusions. Most children were reluctant to record anything while involved in experimenting; they were impatient to get on to the next part of the activity. This was particularly evident in the exploration phase. When the urban school teacher helped the children plan a table or the like for recording data from tests, the children tended to use these properly, but some children opted out of this by leaving it to another member of the group. The same children tended to avoid making written descriptions of work done or conclusions reached. Many children showed signs that they found this latter form of recording boring and tedious; but conversely, a small number of children seemed to enjoy it. This raises questions about not only the purpose of recording data, descriptions and conclusions, but also the

form the recording should take, and the use to which it is to be put in the wider context of the approach. Teachers' purposes for recording may at times go beyond the needs of the investigation.

For example, a teacher may feel an obligation to have the children prepare an attractive display or book to show administrators and/or parents. This particular perceived obligation was in the back of the mind of the urban teacher during the trial.

- (vi) Evaluation. Criteria for evaluating the success of the LISP(P) approach were proposed by one of the teachers who undertook the trial. This was the first time that a set of such criteria has been listed. When refined it may well be of use to other teachers trying the approach.

ISSUES WHICH AROSE FROM THE TRIALS

Two main issues became evident from this second set of trials.

1. Degree of familiarity with the teaching approach influences how well a teacher uses a guide booklet

The first trial of the guide booklets (Appleton, Hawe and Biddulph, 1984) revealed how teachers unfamiliar with the approach did not incorporate critical elements of the approach in their teaching. In this second set of trials, all teachers were familiar with the approach before they began, and were able to use the booklets as intended. Further, the teacher (J.F.) who had had most experience with the approach was able to vary it to suit his own situation. This flexibility provided more opportunity for direct challenging of children's ideas. Perhaps even more significantly, the three teachers have continued to use the approach with other topics (and even other subjects) where no guide booklets are available.

2. The teaching approach can be confirmed as a viable approach to science teaching, provided certain conditions can be met

Earlier trials (Biddulph and Roger, 1983; Biddulph and McMinn, 1983) established the feasibility of the approach. The present trials demonstrated that, given certain modifications and prior conditions, the approach is a viable one. Prior conditions which seem to be required are:

- (a) The teacher needs to be thoroughly familiar with the approach before commencing. There is a dilemma in this of course: to become familiar with the approach a teacher really needs to try it out. It would seem that some kind of transition phase may be needed rather than expecting teachers to achieve instant competence in the use of the approach.
- (b) The teacher needs to clarify with the children at the beginning what the topic is about. This may be simply a matter of telling them what is encompassed by the topic, in this case that objects will be considered 'floating' if they are on top of the water, partly immersed, or fully immersed but freely suspended in it.
- (c) The teacher needs to challenge children to clarify and if necessary redefine their questions so that they focus on questions which are answerable. In the same way, the teacher needs to challenge children to design investigations that will provide data that the children need to answer their questions.
- (d) The teacher needs to be able to adjust the level of his/her teaching to take into account both the children's experience in working this way, and his/her own management skills. Initially, this may mean limiting the number of questions selected, the number of investigations carried out, and the number of small groups functioning.
- (e) The children need to be given sufficient time for individual exploration early in the testing. This will probably be given before questions are gathered but may also be provided immediately prior to the commencement of an investigation.

- (f) The teacher needs to become actively involved in challenging children's ideas in all phases of the teaching sequence. Such challenging will occur when a teacher is working with an individual child, with a small group of children, and with the class as a whole group.

CONCLUSION

The findings from these trials indicate that, given some compromise with the suggested approach, the guide booklets can be re-written to convey a teaching sequence and strategies which are likely to be within the capabilities of teachers - provided they are not intended to stand alone.

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6548C

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APPENDIX 1

FLOATING AND SINKING SURVEY

NAME: SCHOOL:

DATE: CLASS: ROOM:

1. WHY DO SOME THINGS FLOAT?

2. WHY DO SOME THINGS SINK?

3. WHEN YOU FILL A FLOATING MATERIAL WITH WATER IT WILL:

Sink
Float lower
Float same
Float higher

4. WHEN FLOATING MATERIAL HAS A HOLE IN IT, IT WILL:

Sink
Float lower
Float same
Float higher

5. WHEN AN OBJECT IS MUCH LONGER IT WILL:

Sink
Float lower
Float same
Float higher

6. WHEN THE WATER IS MUCH DEEPER AN OBJECT WILL:

Sink
Float lower
Float same
Float higher

APPENDIX 2

THE RURAL SCHOOL CHILDREN'S QUESTIONS ABOUT FLOATING AND SINKING

Questions seeking clarification of meaning of 'floating'

1. Are parachutes floating in air?
2. If something is on the top surface of the water, is that called floating?
3. If something is not touching the bottom and yet is not at the top of the water, is it floating?
4. If something is in the water with only its top surface level with the top surface of the water, is that called floating?
5. When any animal dives or jumps into the water, are they floating or sinking?

Questions seeking information

1. Do things float better in shallower water than in deep water?
2. Can liquids float on or in other liquids?
3. Can things float in something that is not water e.g. air, oil, gas, petrol, lava, milk?
4. Does a thing have to have air in to float?
5. If a true fish stops moving does it rise to the surface? Is it the movement that keeps it under?
6. Does the shape of an object make any difference to whether it floats or not?
7. Do some shapes help things that wouldn't float to float?
8. Does all wood float?
9. Do boats have to be moving to be floating?
10. Does all fat sink?
11. Do the chemicals things are made of help them float?

Questions seeking explanations

(a) Why various objects/materials float

1. How come a cork floats?
2. Why does wood float - 'cause wood is really heavy?
3. How come fire can float on water?
4. Why does oil and petrol float on water?
5. Balsa wood glue makes a sort of cover on the water, and some paints do the same. Why is that?
6. Why does a fish or a whale float?
7. How do ice bergs float in the water?
8. How do life jackets float?
9. Why do dead fish float?
10. How do cargo ships float?
11. How come when the cargo holds are full a boat still floats?
12. Why do little boats with huge outboard motors stay afloat?
13. How come big things like water melons can float?
14. Why is it that human beings can float even though they are not full of air or polystyrene?
15. Why does cotton wool hit the bottom, then float on top again?
16. Why do empty plastic bottles pop out of the water and empty glass jars sit half-way in the water?

(b) Why various objects/materials sink

1. A piece of plastic sank. Why did it sink?
2. Why do light things like wire gauze sink rather than float?
3. Why does soap stick to the bottom of the bath?

(c) Why various objects/materials float/sink

1. Why do some people float and some people sink?
2. How come some balls float and some balls sink?
3. Why does water-logged pumice sink, and unwater-logged pumice float?
4. Why does dry cotton wool float while soaked cotton wool sinks?
5. Play-dough when it's rolled into a ball goes right to the bottom, but when it's a boat shape it stays floating. Why is that?
6. Why does a little pebble sink and a larger object float?
7. Why do some things float when they are one way up and sink the other way?
8. How come if you fill a container with water it sinks but when you blow air in, it floats?
9. How come that something like a log that is floating can be made to sink when a person gets on it?
10. Why do some things float and other things sink?

(d) Why various objects behave as they do

1. Why do empty containers tip over when we put them into water?

APPENDIX 3

THE URBAN SCHOOL CHILDREN'S QUESTIONS ABOUT
FLOATING AND SINKING

Questions seeking information

1. Does the shape of an object make any difference to whether an object floats or sinks?
2. Can things float in other liquids?
3. Will an egg yolk sink or float?

Questions seeking explanations about floating

1. Why do some things hollowed out float?
2. Why do large metal objects float?
3. Why do some large heavy things float?
4. Why does an onion go down and come up again and float?
5. Why do heavy logs we can't lift, float?
6. Why does a hollowed-out object float face-up, but when you put face down, half-floats?
7. Why do flat things float?
8. Why do fat people float better than thin people?

Questions seeking explanations about sinking

1. Why does a button move from side to side as it sinks?
2. Why does some wood sink?
3. Why do small pieces of wood sink after being in water?
4. Why did an egg make things in a bag sink?

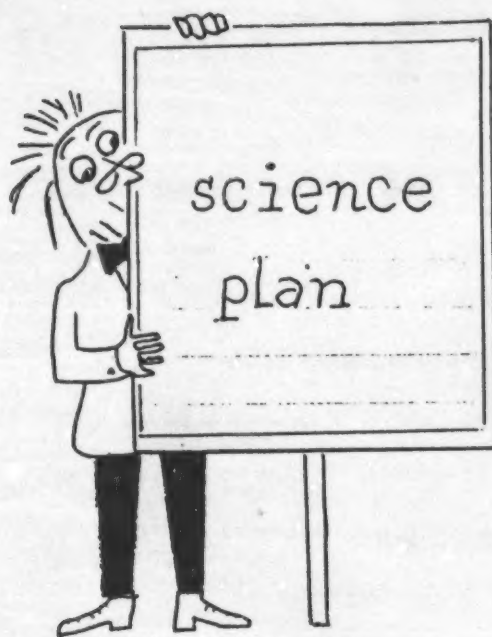
Questions seeking explanations about floating and sinking

1. Why do things float and sink?
2. Why does the inside of an acorn sink when the outside (shell) doesn't?
3. Why do some stones sink and some stones float?
4. Why does a raw egg sink and a boiled egg float?
5. Why does a potato sink and an apple float?
6. Why do humans float but some animals don't?
7. Why does a wooden button sink and a plastic one float?
8. Why do ants sink, and then come up to the top?
9. Why do some insects float and some don't?
10. Why does cotton sink, and wood float?
11. Why does an empty yoghurt container float but a full one sinks?

Questions seeking explanations about other phenomena

1. Why does a heavy thing become lighter in water?
2. Why does your leg get heavy in the bath?

APPENDIX 4



1. Write down your name and who you will be working with.
2. Write down the question you are investigating.
3. Write down all the ways you could find an answer to your question.
4. Write down how Mrs Roger can help you with your investigation.
5. Write down how you will record your investigations.



science
plan

your investigations

Today we begin our investigations.

The first thing we need to decide is:

What we want to find out.

The second thing we need to decide is:

What we are going to do to find this out.

REMEMBER!!

It may take you more than this one lesson to do your investigation so just concentrate on one important thing you are going to investigate today. It is probably best to do one activity a day and then record it.

Fill in this for today

1. The important thing we want to do today is

2. To find this out we are going to

recording



Record EVERYTHING you do.

All the investigations are valuable.

STEPS TO RECORDING

1. While you are doing your investigations write notes about everything you do. Do diagrams as well.
2. When you have finished your day's investigation write your notes up in full.
3. Work on your final presentation e.g. do headings, frames, diagrams etc.

FINAL PRESENTATION

Your final presentation must contain the following:

- A. A bold heading : probably your question.
- B. A record of all your investigations with diagrams etc.
- C. A conclusion : an answer to your questions and your reasons for this answer.

APPENDIX 7

DOES THE SHAPE OF AN OBJECT MAKE A DIFFERENCE TO
WHETHER IT FLOATS OR SINKS?

• IN YOUR PLAN FOR YOUR INVESTIGATION,

• Have you decided what sort of material to try which you can make into different shapes easily?

Have you decided what shapes to try?

Hint: Don't forget to try different shapes made from the same material.

Have you decided how to check whether each shape floats higher or lower?

You may like to try this again with some other material. Just because something happens with one material doesn't mean it will happen with them all.

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